NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Mitigation of Vehicle Fast Charge Grid Impacts with Renewables and Energy Storage




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Project ID VSS114

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Overview

Timeline

Project Start Date: 10/1/11
Project End Date: 9/30/14
Percent Complete: 60%

Budget

Total Project Funding: $220K
DOE Share: 100%
Contractor Share: 0%

Funding Received in FY12: $120K

Funding Received in FY13: $100K

Barriers

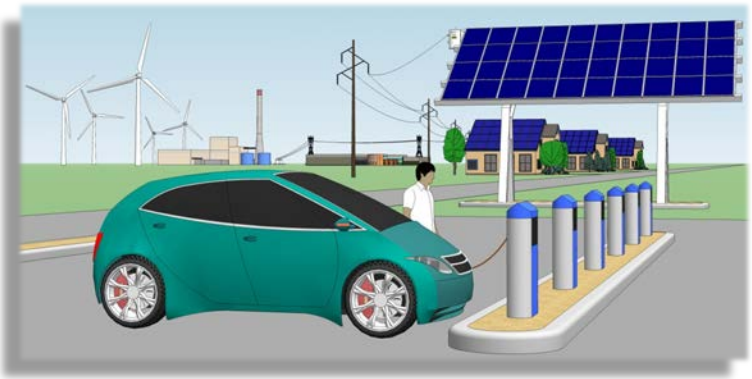
- **Barriers addressed**
  - Uncertainty of fast charger usage/market demand
  - Grid impact mitigation system (PV + battery) design

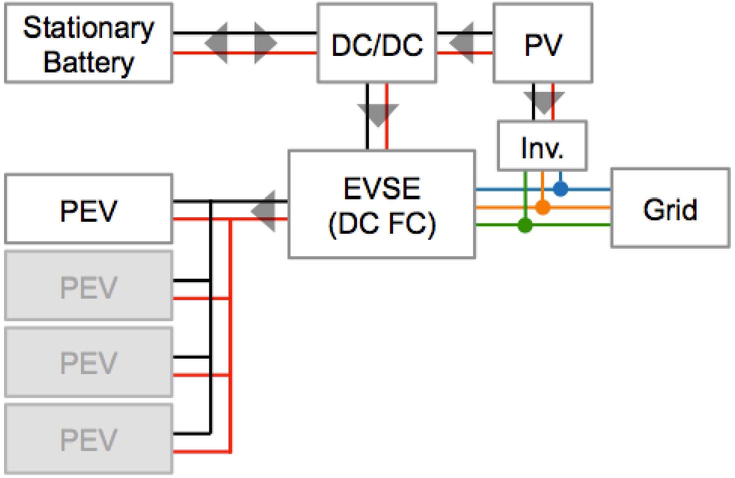
Partners

- Interactions/collaborations
  - Aerovironment, Inc.
  - Mitsubishi North America
  - Portland General Electric
  - Kanematsu

Relevance

- Identify fast charge system benefits as aligned with VTP goals
  - Economically expand electrified travel miles
  - Develop renewable DC Fast Charge station design tool
- Address fast charging concerns/barriers
  - Minimize power spikes on the local grid
  - Avoid exacerbating peak demand
  - Optimize system cost-effectiveness/business model
  - Quantify battery utilization





Milestones

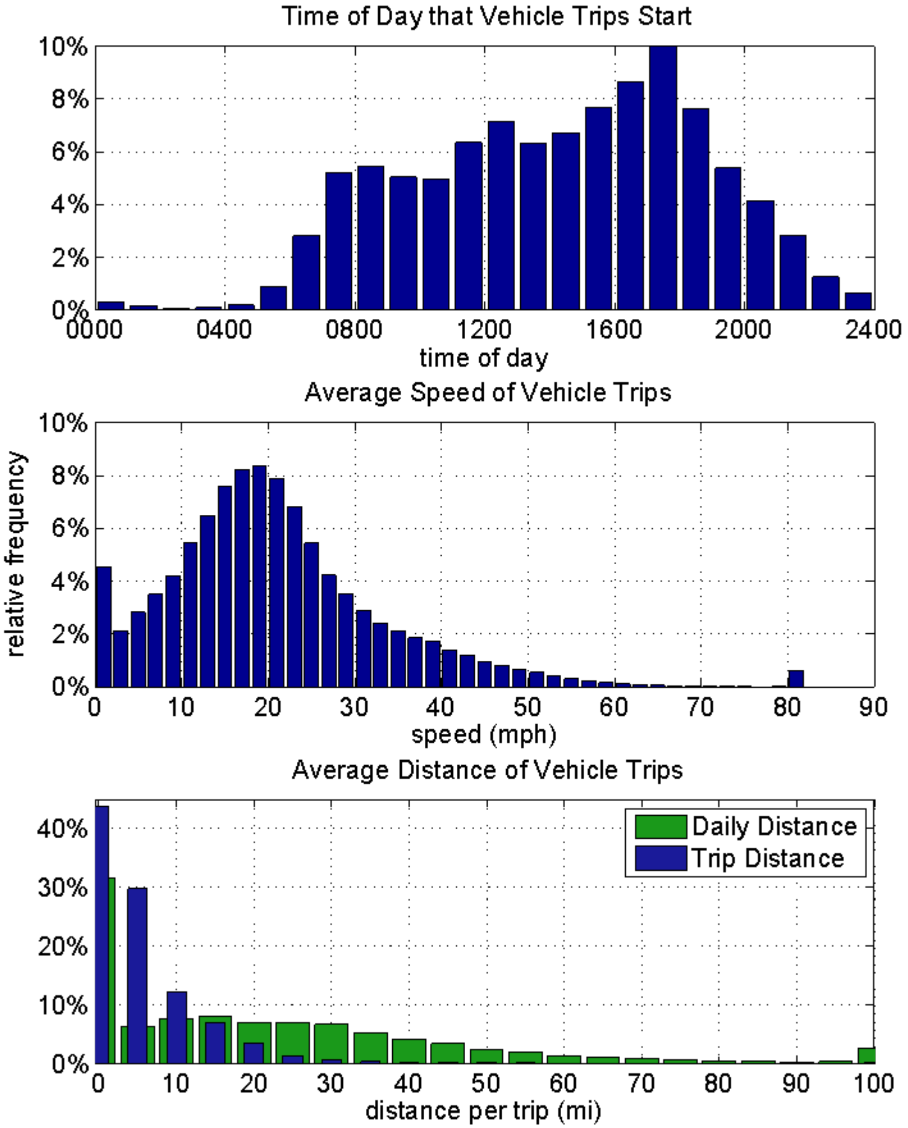
Date	Milestone or Go/No-Go Decision	Status
Aug 2013	Task 1: Communications and Integration of Fast Charging with Renewables Report Developed Offering Technology and Strategy Guidance	On-Track

NREL PIX #20040

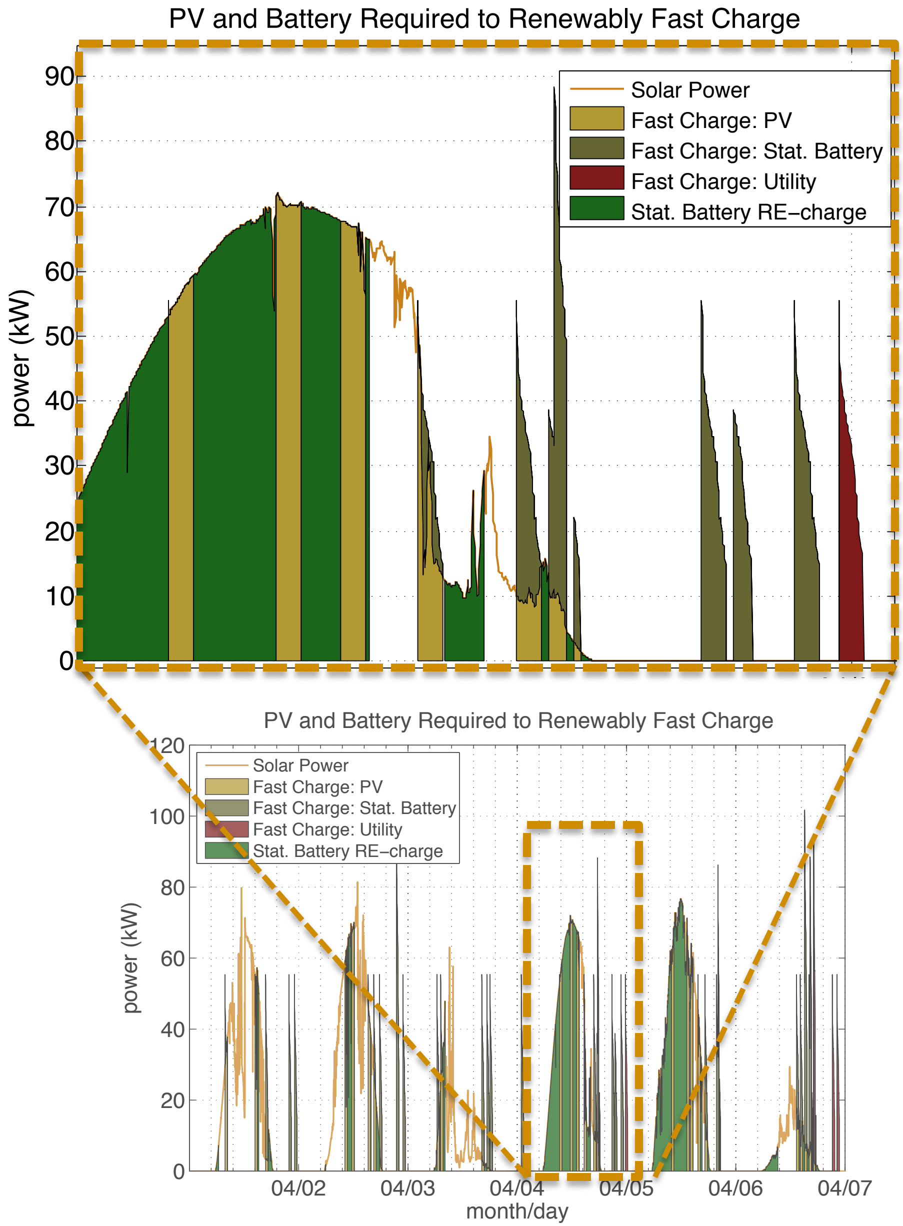
NREL PIX #20041

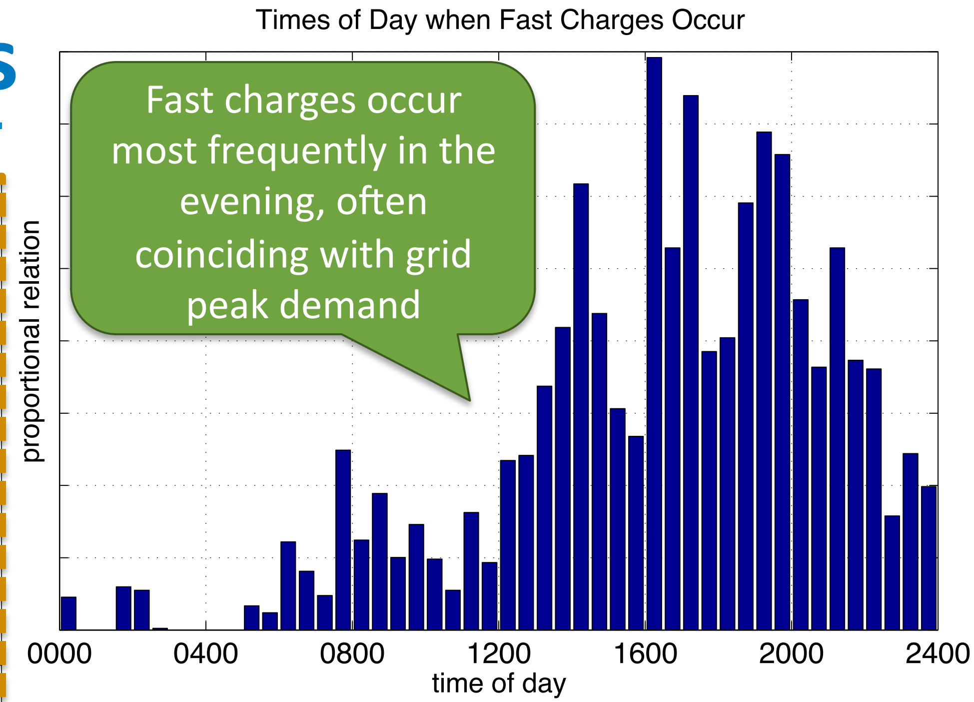
Approach/Strategy

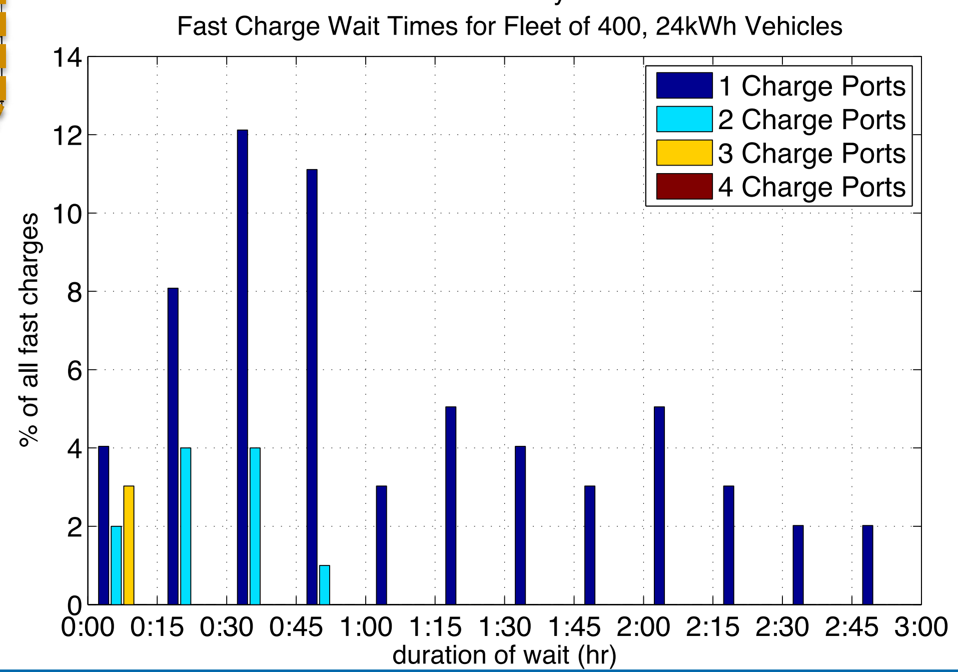
- Develop a mixed-integer optimization model identifying the optimal (minimum life-cycle cost) fast charge system
  - Sizes the fast charger (# ports), PV system and stationary storage
  - Dispatch strategy at 15-minute intervals
  - Driver utility indicate preference to initiate fast charge
  - Incorporates demand charges, varying electricity rates
  - Ultimately, will utilize Puget Sound Regional Council *Traffic Choices Survey* – (see data at right)
    - GPS tracking of 445 vehicles over 3-month control period
    - Include all daily trips (~150,000 total)
  - Assume home charging occurs most often (with occasional "forgetting to plug in" factor)



FY 12 Study Findings

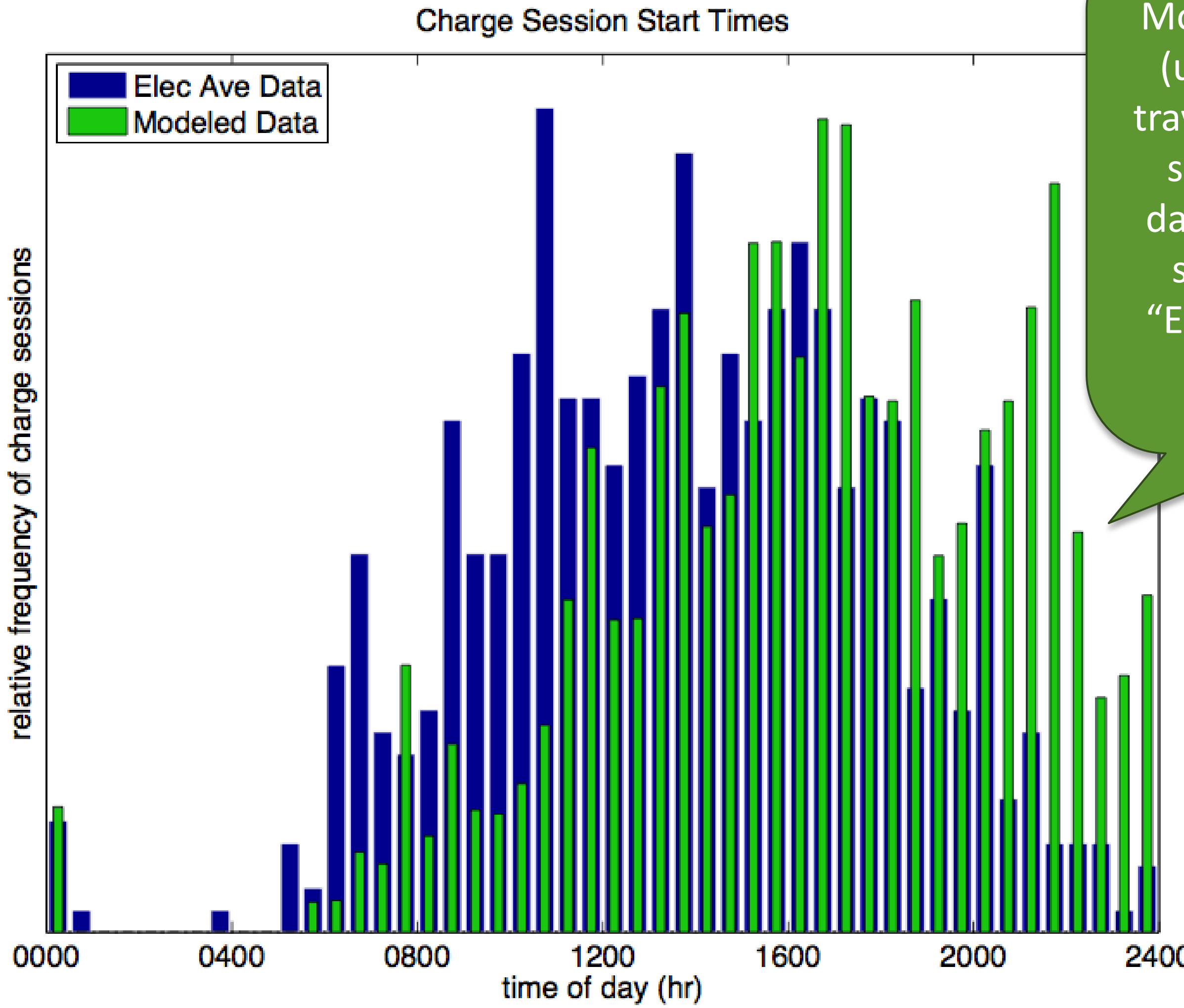






Real-World Data Comparison

- Modeled charge times closely match real-world experience



Modeled fast charges (using Puget Sound travel survey data) are shifted later in the day, relative to those seen at Portland's "Electric Avenue" DC Fast Charger

Technical Accomplishments and Progress

- Initial runs provide an optimal solution
- Minimum-cost solution reflects real-world fast charge challenges:
  - Model tends to build maximum PV system, and sell all electricity to the grid
  - Model tends to not build fast charger or storage but charge at home exclusively.
  - Forcing model to build fast charger (via forget factors or long distance travel requirements) results in minimal fast charge ports; still no storage

	6am		6:30		7am
Time Period	25	26	27	28	29
Vehicle 1	CH/Idle	CH/Idle	Driving	Driving	Idle
Vehicle 2	0.5	0.5	0.5	Driving	Driving
Vehicle 3	0.2	0.2	Driving	Driving	0.7
Vehicle 4	0.2	0.2	0.2	0.2	0.2
Vehicle 5	CH/Idle	CH/Idle	CH/Idle	Driving	Driving
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Overall status: **Finished global search.**

LP relaxation:		Global search:	
Algorithm:	Simplex primal	Current node:	1045
Simplex iterations:	5960	Depth:	184
Objective:	-3.09325e+006	Active nodes:	0
Status:	Unfinished	Best bound:	-3.09325e+006
Time:	7.5s	Best solution:	-3.09325e+006
		Gap:	0%
		Status:	Solution is optimal.
		Time:	25.0s

Technical Accomplishments and Progress

Design Tool Analyzes Full System Life Cycle Performance and Cost

Driver utility
”Forget” factor
Scheduled miles driven

Max/min battery SOC
“2C” charge/discharge rate
15min time intervals

Varying electrical rates
Demand charges
Varying PV resource

Optimizer – technologies compete every time period
Outputs most efficient system possible

Entire life cycle costs
- Infrastructure
- O&M
- User fees
- Sellback costs
- Demand charges

System sizes (PV/storage)
Number fast charge outlets
15min optimal dispatch strategy

Vehicle state (FC, Idle Driving, Chghome)
SOC Battery (storage)
SOC (vehicle)

Collaboration and Coordination

- Gathered over a full year of DCFC usage from the Portland "Electric Avenue" station:
  - Kanematsu fast charger
  - ~100 unique users
- Pursuing data from Aerovironment public DCFC stations
- Paper presented at EVS 26 communicating usage, benefits, and potential concerns
  - If users treat fast charge stations like conventional fueling stations, high utilization may exacerbate local peak electricity demand.
  - Identified concern mitigation with PV and stationary battery

NREL PIX #20144

Proposed Future Work

Next Steps

- Incorporate the full fleet of vehicle drive profiles
- Explore design space across regions to capture a range of:
  - Solar availability
  - Utility rate schedules

Future Work

- Determine optimal results of multiple runs involving varied charging fees, demand charges, utility rates, PV resource availability, life-cycle and infrastructure costs rates
  - Such that rule-of-thumb optimal storage, PV, and fast charge sizes can be found
- Incorporate regional variation with alternate travel profiles
- Design, then emulate system with hardware-in-the-loop at NREL Vehicle Testing and Integration Facility

Summary

- FY12 simulations with multiple data sets demonstrated the need to incorporate PV and storage with fast charging to meet large fleet charging demands without grid impact.

- A fundamental question is: “How big should the PV, storage and fast charge overall system be?”
  - Supplying the wrong sizes and/or strategy could be inefficient and degrades fast charge station value proposition

- FY13 efforts are focusing on answering design and related economics of the fast charge system with integrated renewables.